CORPORATE NAVSEA FY99 IR&D TECHNOLOGY NEEDS

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CLICK ON ORGANIZATION NAME TO LINK TO THEIR NEEDS DOCUMENT AND CONTACTS

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DEPARTMENT OF THE NAVY

NAVAL SEA SYSTEMS COMMAND
2531 JEFFERSON DAVIS HWY
ARLINGTON VA 22242-5160

IN REPLY REFER TO

3900
Ser 05R/018
10 Dec 99

Dear Colleague:

SUBJECT: CORPORATE NAVSEA FY99 INDEPENDENT RESEARCH AND DEVELOPMENT (IR&D) NEEDS

Enclosure (1) contains a summary of Corporate NAVSEA's IR&D Needs for FY99. The purpose of this letter is to provide a consolidated list of technology needs to serve as guidance for the DoD Contractor Independent Research and Development (IR&D) communities. These needs are a collection of projected enhancements that will be required for improved warfighting capability and cost effectiveness.

A compact disk (CD) format is used to present the needs in order to enable direct user cross correlation searches of the data provided. Enclosure (1) has been developed in Adobe Acrobat Portable Document Format (pdf) which is available free from Adobe's website www.adobe.com. The Adobe Acrobat software can be used to view, print and/or navigate throughout the document via embedded electronic links and the table of contents. In addition, there is a listing of relevant keywords. The Adobe Acrobat find feature can use these keywords to find related technology needs.

This document will be made available to those DoD contractors who have IR&D programs or desire to participate in the Navy's Potential Contractor Program (NPCP). Copies can be obtained from the Navy Acquisition Research and Development Information Center (NARDIC).

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Additional information on a specific subject can be obtained by contacting the individuals listed in the enclosed document at the beginning of each section. For general information regarding this document, and any suggestions for improvement, please contact Mr. Carl Pohler, Corporate NAVSEA IR&D Program

Manager, (703) 602-3003 Ext. 443, or Mr. Joe Stegall, Corporate NAVSEA IR&D Coordinator, (703) 602-3003 Ext. 440. Both can also be reached at NAVSEA'S Corporate Research and Development Division, SEA 05R1, via e-mail: pohlerch@navsea.navy.mil or stegallj@navsea.navy.mil.

Sincerely,

ANTHONY D. NICKENS
Director, Corporate Research & Development Division

Enclosure

PEO AIRCRAFT CARRIERS

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TOPIC TITLE: RAPID AIRCRAFT TURNAROUND

Time Target: Mid- to long-term

Brief Description: Aircraft Carrier sortie generation rate is driven b y several factors, one of which is the ability to service (e.g., rearm, refuel and perform minor maintenance) aircraft. The present servicing process requires a number of steps including de-arming forward firing weapons, taxiing to an initial parking spot, chock and chain securing the aircraft to the deck, weapons loading, refueling, troubleshooting, maintenance, canopy washing, liquid oxygen servicing, alignment of the inertial navigation system, manning the aircraft, conducting pre-flight checks, taxiing to the catapult, estimating the weight of the aircraft, and re-arming forward firing weapons. Provide an automated, integrated flight deck aircraft servicing system that performs the required weapons handling, refueling aircraft mission load-out, servicing and pre-launch functions, is less dependent on personnel, and minimizes the need to re-spot of aircraft.

TOPIC TITLE: FLIGHT DECK NOISE ABATEMENT

Time Target: Near- to mid-term.

Brief Description: Provide a reliable, sailor-friendly noise abatement system that protects personnel on the flight deck from high decibel levels and is less intrusive than existing techniques.

TOPIC TITLE: SHIP STRUCTURES

Time Target: Mid- to far-term

Brief Description: Technology components are needed to lower the cost of ship construction, dynamic stability, and damage control response. Particular areas of interest include:

- Ship Construction Techniques or Support Capabilities
- Lightweight Structural Components
- Dynamic Ship Stability (After Damage)
- Ship Motion Control Systems
- Magnetically Attached Hull Patches
- Flooding Casualty Response Mechanisms
- Automated Conflagration Response Mechanism

TOPIC TITLE: MATERIALS

Time Target: Near-, mid- and far-term.

Brief Description: Technologies and innovative techniques are needed to address materials capable of withstanding higher jet exhaust temperatures, and possessing the ability to disapate heat quickly and without cooling water. In particular, materials and techniques of interest include:

- Radar Absorbing Structures (RAS)
- RAM Materials

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- EM Shielding Materials
- Composite Materials and Repair
- Coatings
- Corrosion Control
- Corrosion Resistant Materials and Techniques
- Paint (interior and exterior)
- Surface Coatings
- Abrasion Resistant Materials
- Synthetic Materials (polyethylene)
- Non-Skid and Flight Deck Surfacing

TOPIC TITLE: C4I APPLICATIONS

Time Target: Mid- to far-term.

Brief Description: Technology components are needed to provide increased processing speed, bandwidth capabilities, and overall information accuracy related to discrete C4I functions. Additionally, lower cost approaches to achieve current or improved C4I application capabilities are needed. Specific examples of C4I functions of interest include: IFF Discrimination for Close Flying objects; IW/EW/NCID Data Meld; Laser Spectrometer (For IFF Applications); Low RCS Target Radar; Mission Planning; Organic capability for the battle group to perform large area surveillance and reconnaissance; Real Time Kill Assessment; Spectral Management; Total Situational Awareness; Alternatives to GPS (precise relative grid positional data).

TOPIC TITLE: C4I ELEMENTS

Time Target: Mid- to far-term.

Brief Description: The open system approach to developing the Carrier computing and communication infrastructure allows independent development of C4I elements. Technology components are needed in each layer of the OSI seven-layer model (display, applications, processing, Operating system, network, network operating system, and transmission media). Specific areas of interest include: Artificial Intelligence and control technology to minimize cascading damage to critical ships systems; Communication media to reduce latency in Theater Wide Operations; Data Fusion; Advanced Displays (large screen, high resolution, touch screen, etc.); Wireless Communications; Electronic Processor to EM Transmitter/Receiver Interface.

TOPIC TITLE: ADVANCED COMPUTER ARCHITECTURE CONCEPTS

Time Target: Mid- to far-term.

Brief Description: Technologies are needed to provide actively reconfigurable computer systems architectures, interconnection networks, and operating systems with multi-level security, data compression, multi-function displays/controls, functional resource sharing and dynamic computing asset allocation. The assumption is that these systems will use COTS equipment.

TOPIC TITLE: REMOTE SENSING

Brief Description: Technologies are needed to provide systems that aid/assist or replace people in manpower intensive activities. Specific areas of interest are: remote control/monitoring of shipboard systems; handling of stores, weapons, cable, equipment, etc.; underway replenishment and strike down. Robotic systems must be quickly reconfigurable to perform multiple tasks: Remote Monitoring, Remote Architectures, MEMS Sensors.

TOPIC TITLE: MEDICAL

Time Target: Mid- to far-term.

Brief Description: Technology components or techniques are needed to provide remote or shipboard medical and dental diagnosis, treatment, and/or follow-up. Technology is needed to support all routine health services as well as those emergency services that can be expected in a shipboard or wartime environment.

TOPIC TITLE: LOGISTICS

Time Target: Near-, mid- and far-term.

Brief Description: Technology components are needed in all areas of Logistics Support. Particular areas of interest include: Advanced Cargo Handling; Automated Heavy Component Handling; Shipboard Printed Circuit Board Production; and Training.

TOPIC TITLE: DESIGN TOOLS

Time Target: Mid- and Far-Term.

Brief Description: Discrete modeling techniques and specific algorithms modeling physical phenomena, system performance, and ship to environment interactions are needed. Additionally, methodologies are needed to merge various models into a common view and to transition modeling results directly to design process products. Specific areas of interest include: Electromagnetic Models; Infrared Modeling; Integrated Hull, Propulsor and Appendage Modeling Systems; Magnetic Modeling; RCS Geometry; RCS Modeling; Wake Flow Prediction and Control.

TOPIC TITLE: ENVIRONMENTAL

Time Target: Near-, mid- and far-term.

Brief Description: Technology Components are needed to ensure that Aircraft Carriers and all of the associated systems can meet or exceed all applicable foreign and domestic environmental regulations. Areas of concern include: Environmentally Compliant Lubricants; Environmental Seal Materials; HAZMAT Collection, Handling, Storage and Disposal; Waste Treatment; Solid Waste (plastics, paper, etc.); Steam/Oil & Water/Oil Separators; Topside Deck Cleaners.

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MAGNETOSTRICTIVE SMART MATERIALS

Short Term: For use in control systems.

Long Term: Rudder control, Screw control by change of angle of attack via embedded magnetostrictive actuators.

RHEOLOGY

Short Term: Slip rings torque converters, clutches, circuit breakers and switches, shock and recoil mitigation.

Long Term: Seismic mitigation, active suspensions, leakproof piping and disk brakes.

ADVANCED COMPOSITES

Short Term: Heat sinks, thermal management, lightweight structural components, advanced gun barrels.

Long Term: Missile structures, topside components, advanced gun barrel liners, advanced surface coatings (various applications), piping for process industries.

ELECTROSEPARATION

Short Term: Environmentally compliant oil filtration with auto recycle capacity (also organic cooling fluids.)

Long Term: Biodetection capability.

PHOTONICS

Short Term: Photonic crystal for optical applications.

Long Term: Photonic crystal for computer laser applications.

PULSE POWER

Short Term: Support Guns – Electrothermal, i.e. Rail guns.

Long Term: Medium caliber round gun family and system for littoral, self-defense specialized guns and gun systems.

OFFICE OF SUBMARINE TECHNOLOGY

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SUBMARINE HM&E NEEDS

Submarine technology needs for HM&E can be found in the Office of Naval Research BAA 99-024, "Innovative Technologies for Hull, Mechanical, and Electrical Systems." This BAA can be found at: www.onr.navy.mil/02/baa

SUBMARINE C4ISR NEEDS

	Near Term	Far Term
Command and Control		
	Tactical Tomahawk Comms/Control	Dramatic Manning Reduction in the Attack Center (50% Reduction) through Automation
	TMA Improvements	Total Situational Awareness
	Advanced Torpedo Control Displays	CINC/NCA Interoperability
	Tactical Data Fusion Improvements	Network-Centric USW Improvements
	Automated Tactical Information Management	Realtime Common Tactical Picture
	Command Display and Decision Support	Battlespace Visualization, Assessment, and Planning Improvements
	Integrated Vulnerability Management	Improved Workstation HMI
	Multi-Warfare TDA/Engagement Planner	Cognitive Workload Management and Automation
	Network-Centric Undersea Warfare	Organic UAV/UUV Command and Control
		Common C3I System for all Submarines
Communications		
	Two-Way Comms (UHF) without Mast	Seamless Comms with Joint Operations
	Automated Radio Room for VA Class/SSNs	High Data Rate with Stealth
	Limited Exposure at Speed and Depth	High Data Rate Comms at Speed and Depth
	Exposure Time <5 Minutes	Exposure Time <1 Minute
	JTF Connectivity	SOF Off-board Video Communications

SUBMARINE C4ISR NEEDS		
	Near Term	Far Term
Communications (cont.)		
	Antenna Data Rate: Rx= T1; Tx= 512 kbps	Antenna Data Rate: Rx = T3, Tx = 6 Mbps, (By year 2010)
	Optimize Satellite Data Rate	Antenna Data Rate: Rx = 10 Gbps, Tx = 10 Gbps, (By year 2020)
	Anti-Jam (MILSTAR/KY-766)	Anti-Jam on all Bands
	LPI/LPD: ELF/VHF/HF/VHF/UHF/SHF	Multiple Links; Simultaneous Off-Board Sensor and Joint Communication
	Full Participant in Network-Centric Warfare	Real Time Video Transmit/Receive between UUV/UAV/BG
		Support of Simultaneous Communications Links
		Signature Reduction at Periscope Depth
Computers		
	Controlled Access Security	Verified Protection and Security
	Common Tactical Information Distribution System Structure throughout Submarine Force	
Intelligence, Surveillance, Reconnaissance		
	Offboard Sensor Control (UUV/UAV)	Enhanced Stealth
	BiStatic Radar Intercept	Enhanced Surveillance with Increased Sensitivity
	Precision Radar Direction Finding	Digital Radios for Improved Communications
	Improved Signal Intercept Capabilities	High Density Monolithic Microwave Integrated Circuits (MMIC)
	Enhanced Vulnerability Assessments	High Probability of Signal Intercept

SUBMARINE C4ISR NEEDS		
	Near Term	Far Term
Intelligence, Surveillance, Reconnaissance cont.		
	Passive Surveillance Technology	Intercept LPI Signals
	Improved ESM Operational Effectiveness	High System Sensitivity
	Phone Communications Intercept Capabilities	High Dynamic Range (Over 110 db)
	INMARSAT	Improved Signal Processing for Identification and Exploitation
	Frequency Coverage Extension	Improve Situation Awareness and Strike Capability
		High Data Rate for SATCOM Antennas with Associated Transmit/Receive (T/R) Modules
		Enhanced Global Communications

PEO TSC - THEATER SURFACE COMBATANTS PMS 429 – NAVAL SURFACE FIRE SUPPORT PROGRAM

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TOPIC TITLE DUAL PURPOSE PROJECTILES

Time Target: Mid-term

Brief Description: Demonstrate land-attack and ship defense projectiles (A single common projectile or a high degree of commonality between the two types.). Capability is needed against small, maneuverable surface threats (such as Boghammars, and jet-skis) large ships, small aircraft (such as slow helicopters and UAVs) and anti-ship missiles. Minimum range limits are important.

TOPIC TITLE GUN IMPROVEMENTS

Time Target: Mid- to long-term

Brief Description: Demonstrate gun improvements and associated technologies to extend range, reduce time to target, increase payload, increase firing rate, reduce magazine volume and weapon module volume (including swept volume, firing arc, and blast-restricted zones), reduce logistic burdens, reduce manning, reduce infrared and radar cross-section and reduce cost. Also applicable to this area would be automated magazines; high pressure gun barrel materials, barrel linings and coatings. Objectives include delivery of gun projectiles to a range of greater than 60 miles.

TOPIC TITLE HYPERSONIC TECHNOLOGIES

Time Target: Mid- to long-term

Brief Description: Demonstrate hypersonic technologies that achieve performance improvements by providing high flyout speeds and terminal velocity kinetic energy lethality effects. In this area are the lethal mechanisms, projectile airframes such as power-body and wave-rider, guidance and control, and propulsion. Deliver a low-cost, unpowered projectile to ranges in excess of 150 miles. Develop technologies to control hypersonic projectiles that furnish adequate control authority to projectiles while at the same time minimize drag.

TOPIC TITLE TARGETING

Time Target: Mid- to long-term

Brief Description: Demonstrate technologies for improved target acquisition, integration of targeting data from current and in-development battlefield sensors, and display of that data to shipboard decision makers. Improve battle damage assessment, improve detection of troops, vehicles and equipment under cover, in poor weather, or when concealed by smoke or fog. Increase ability to eliminate target location errors resulting from coordinate system misalignments and datum errors. Includes technology to allow use of CEC for counterfire mission against enemy artillery, rocket launchers, and coastal defenses. Develop technologies for long range video relay of data links for loitering gun launched munitions.

TOPIC TITLE ALTERNATIVES TO GPS.

Time Target: Mid- to long-term

Brief Description: Demonstrate technologies for navigation, mitigation of GPS jamming, and attack of GPS jammers. Allow for in-flight retargeting of munitions to update target position or aimpoint using low latency, sensor-to-ship-to-weapon communications. Low cost L Band/S Band uplinks for guided projectiles to enable navigation via GPS Satellite and concurrent dynamic retargeting at either low data rate L Band or high data rates at S Band. Projectile link receivers need to be very compact and to share system for GPS navigation.

TOPIC TITLE ADVANCED AVIONICS

Time Target: Mid- to long-term

Brief Description: Demonstrate advanced avionics technologies that provide significant enhancement of telemetry, guidance and control, and processing functions. Advanced telemetry technologies of interest include near real-time (e.g. data received and displayed less than 10 seconds after occurrence), extreme multi-channel and high speed telemetry systems which demonstrate near real-time telemetry (IR, visible) assessment capability allowing for wide bandwidth transceiver/receiver link with the kinetic warhead. Advanced G&C technologies of interest include an Integrated GPS Aided Micro Inertial Measurement Unit, which will provide a low cost navigational quality integrated GPS aided micro IMU with the fast acquisition (e.g. GPS data acquired in less than one second) of a GPS without the need for a hot start. Processing technologies of interest are those which can support an extreme level of computations at extremely high speed, with little weight, volume or power needs.

TOPIC TITLE ADVANCED WARHEAD DESIGN/LETHALITY ENHANCEMENT.

Time Target: Mid- to long-term

Brief Description: Demonstrate innovative advanced lethality approaches that provide quantum enhancement of the probability of kill and/or enhance kill assessment capabilities. Examples include innovative deployable masses or structures, reactive material structures, scalable munitions with selective yield to optimize effectiveness and minimize collateral damage, and kill assessment technologies. Demonstrate advanced warhead designs with increased lethality enhancement that includes reduced space and weight requirements, maintains or increases performance, and uses reactive materials or explosively formed penetrators. Technologies for smart submunitions such as low cost terminal seekers and guidance systems for "tuna can" sized submunitions capable of being despensed from loitering munitions such as FASM. Focus should be on achieving high probability of kill for any submunition warheads, i.e. smart submunitions.

TOPIC TITLE ROBOTICS AND AUTOMATION

Time Target: Mid- to long-term

Brief Description: Demonstrate capabilities for remote control and handling of shipboard equipments/systems, handling of heavy munitions, underway replenishment and strike down.

TOPIC TITLE ADVANCED PROPELLANTS

Time Target: Mid- to long-term

Brief Description: Demonstrate advanced propulsion concepts such as gel/uncured propellants, light gas, traveling charge, or modular caseless charges. Cooler burning advanced propellant formulations with high gas generation rates are needed for hypervelocity projectiles. New ignitor concepts for high energy compacted propellants. Emphasis should be placed on developing and demonstrating propellants that achieve muzzle velocities in excess of 7000 ft/sec. while still being insensitive and environmentally compliant.

TOPIC TITLE ADVANCED PAYLOADS

Time Target: Mid- to long-term

Brief Description: Demonstrate technologies to allow packaging of smoke, obscurants, non-lethal payloads in to gun launched munitions.

TOPIC TITLE FLEXIBILITY AND ADAPTABILITY

Time Target: Long-term

Brief Description: Demonstrate technologies that make guns, projectiles, and their supporting systems more flexible and adaptable, with lower life cycle costs, using emerging technologies such as micro- and nano-machining, electroheology and non-Newtonian fluids, or sensors operating on unusual bands or signatures (multispectral or hyperspectral IR, higher-order signal processing, acoustic/seismic, or interferrometric SAR, for example); W-band, optical, infrared, laser radar and semiactive laser seekers; automated function; automatic target recognition; modular ship interfaces.

TOPIC TITLE FLYOUT PROPULSION TECHNOLOGIES

Time Target: Long-term

Brief Description: Demonstrate innovative propulsion technologies which have variable thrust capability, thrust cut-off capability, high mass fractions, high energy density, IM/environmental compliance, and low lifecycle costs. Emphasis in propulsion areas should be placed on developing and demonstrating propellant and propulsion system component technologies which are insensitive munitions, environmentally compliant, and maintain high performance capability. Also of interest are technologies that significantly reduce material and fabrication costs, while maintaining high quality parts.

TOPIC TITLE ADVANCED SENSORS AND IR SEEKERS.

Time Target: Long-term

Brief Description: Technologies for the demonstration of advanced sensors and seekers include terminal guidance, aimpoint selection, discrimination, acquisition andfuzing. Additional needs include: Window distortion compensation, (the utilization of adaptive optic approaches to remove shock wave, turbulence, and thermal window distortion from the optic paths) and extended aperture, (simultaneous narrow field of view/wide field of view seeker system yielding high resolution). Demonstrate innovative technologies with the following attributes: multiple color, lightweight, low volume, flexible packaging, lowcryo needs, wide FOV, active jitter control (e.g., controllable elements, MEMS, smart materials, etc.) and low cost. Demonstrate increased high temperature strength of the dome that increases the allowable heat flux on the dome by a factor of three without thermal shock failure. Demonstrate improved rain erosion characteristics, improved thermal isolation of antenna electronics, enhanced immunity to certain types of jammers, and dramatically improvedradome bandwidth.

TOPIC TITLE ADVANCED AND ALTERNATE POWER SYSTEMS

Time Target: Long-term

Brief Description: Technologies for advanced power systems with the capability of supporting extremely long mission duration (>150nmi) which are lightweight, low volume, high energy density, low temperature and have good cost potential. Integration of power systems with other high energy components, such as divert/ACS propulsion and other propulsion systems, is desirable.

TOPIC TITLE ELECTROMAGNETIC GUN

Time Target: Long-term

Brief Description: Technologies associated with power supplies, launcher, payloads, and platform integration associated with large caliber electromagnetic gun.

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PEO USW – UNDERSEA WARFARE

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PEO USW WARFIGHTING SUPPORT OBJECTIVES

PEO USW's specific Warfighting Support Objectives are to measurably improve the Fleet's capability to:

- Detect, classify, localize, counter and/or destroy all classes of threat submarines and torpedoes in all ocean areas including the shallow littoral waters.
- Detect, classify, localize and avoid threat mines in all ocean areas including the shallow littoral waters.
- Detect, classify, localize and destroy low flying, fixed/rotary winged aircraft and small, fast surface craft from a submarine in all ocean areas including the shallow littoral waters.
- Assess the undersea tactical situation via real-time fusion of tactical data acquired from multiple onboard and offboard sensors located on multiple platforms throughout the battleforce.
- Collect, assess and rapidly distribute battlespace intelligence among all warfighting platforms: surface, air and subsurface.
- Identify friend from foe in all undersea related mission scenarios.
- Improved USW readiness through the increased use of simulation in training environments.
- Insure overall platform effectiveness by integration of USW with other warfare areas.

PEO USW CORPORATE OBJECTIVES

PEO USW's specific Corporate Objectives are to provide significantly improved warfighting capability to the Fleet as efficiently and effectively as possible. Specific Corporate Objectives are to:

- Minimize Total Ownership Costs (TOC) for current and future undersea warfare systems subject to a given effectiveness and availability.
- Leverage technology across all systems, weapons and platforms to enhance improvements and facilitate integrated logistics support.
- Improve the fidelity of modeling and simulation based methodologies so Program Managers can confidently rely on these techniques during the design and testing of upgrades to current systems and development of future systems.
- Minimize development time for USW systems to accelerate technology transition and fleet introduction.

PEO USW TECHNOLOGY NEEDS

PEO USW technology needs are identified as requirements most likely to contribute to the successful achievement of the PEO USW objectives outlined in Section 2.0. These needs are continuously assessed, validated and prioritized during the Chief of Naval Operations (N91) sponsored Science & Technology Process. PEO USW needs are categorized as common USW technology needs across all programs and unique USW technology needs attributable to specific programs.

COMMON USW TECHNOLOGY NEEDS

To achieve the PEO performance objectives and specific capabilities required of the subsystems, the thrust for systems/weapons in the undersea warfare area should focus on the following general needs:

- Improved acoustic detection, classification, and localization (DCL) of quiet, slow and/or bottomed diesel submarines in shallow water.
- Improved characterization of operating environments worldwide.
- Better battleforce and other coordination of tactical sonar data.
- Improved mine detection and avoidance capabilities.
- Improved weapon performance in the littorals equivalent to the open ocean.
- Improved torpedo defense capabilities.
- Improved operability/reduced manning.
- Improved integration of multi-sensor/multi-platform data to solve DCL problems.
- Increased emphasis on Simulation Based Design applications to decrease development risk, cost and time.
- Surveillance and intelligence collection in littoral areas. Sensors are required to gather information on ship types, movements and exploitable characteristics, accumulation of potential targeting data, monitoring of electronic emissions and the execution of special forces operations.
- In-situ measurements of physical properties (such as optical backscatter, salinity, temperature, geophysical parameters and bottom type) to validate prediction models, develop sensor deployment tactics and improve the coastal oceanographic databases.
- Improved real time adaptive processing and large aperture arrays.

COMMON ATTRIBUTES FOR ALL TECHNOLOGY NEEDS

It should be noted that development of technology must be consistent with the Open System Architecture (OSA) concepts being worked for both Surface Combatants and Submarines. Additionally, technology development should maximize use of Commercial Off The Shelf (COTS) and/or non-development items (NDI).

Affordability in Exploratory and Advanced Developments necessary to obtain technological solutions will be achieved by the combination of:

- Decreasing both development and subsequent operational and support costs by maximizing use of COTS and NDI equipment, commonality, OSA and simulation based design during 6.2 and 6.3 funded development stages. The Advanced Processing Builds (APB) development environment and interface standards will be used to facilitate rapid transition.

- Decreasing acquisition costs and development cycles by streamlining the acquisition process (tailoring requirements, specifications and data requirements), making use of previously developed 6.3 and 6.4 fundedtestbeds, reducing software costs by developing hardware independent parallel processor programming, and by increasing the use of simulation.
- Understanding where 6.4 and 6.5 funded efforts are making procurement investments and seeking technologies that leverage these procurements.
- Leveraging industry supported technology to improve and shorten the development cycle.
- Reducing manning through automation of the detection, classification, tracking and localization functions; reduction of false alarm probability; and the implementation of advanced data fusion and Human Machine Interfaces.
- Reducing training costs through the use of advances in technology beyond existing on-line and interactive electronic courseware, and embedded training.
- Encouraging teaming (laboratories, industry and universities) to provide cost effective solutions.
- Decrease TOC by maximizing development oftechnologies which have a high potential for reducing acquisition and support costs.

UNIQUE USW TECHNOLOGY NEEDS

Active Sonar Technology Needs (Submarine, Surface Ship and UUV applications)

Automated, adaptive technologies for improved detection, classification, localization and tracking of quiet, low Doppler submarines throughout the water column.

- New acoustic sensor materials that improve wideband transmitter source level and receiver sensitivity while reducing volume and weight.
- The capability to monitor and estimate real time performance for environmental adaptation and optimize system performance.
- Fully coordinated, low frequency and broadband ASW in littoral waters, including the capability for automatic detection, classification and tracking using impulsive sources and legacy sensors.
- Ability to gather acoustic data on the local environment and threat targets without being detected.
- A capability for identification, Friend or Foe, of combatants/weapons in littoral waters.
- A low/mid frequency multistatic capability for enhanced performance in cross layer and downward refracting conditions. Low frequency is defined as from the lower end of broadband impulsive sources to the current operational frequencies of the Low Frequency Active (LFA) transmitter, and mid-frequency is defined as the current operational frequency of the AN/SQS-53C and AN/BQQ-10 (Acoustic Rapid COTS Insertion (ARCI)). High frequency is above the mid frequency band.

- Improved sensor capability for detection, classification, and localization of bottom, moored, and floating mines in littoral waters.
- A capability to characterize the shallow water region, including the capability to obtain bottom profile for in-situ recognition of bottom contours, as well as mines and mine like contacts; a capability to automatically extract and update mine, minefield, and environmental information from a database and display pertinent information.
- Improvements in bottom mapping and collision avoidance systems in shallow water to include the capability to store and retrieve the data, and in the capability to assess range and sector widths for maneuvering.
- A reduction in the false alarm rates relative to detection, classification and localization of all mines, particularly in high bottom-clutter environments.
- A reduction in the manning needed for active sonar detection, classification, and localization. Effort should be expended to develop modern, efficient Operator/Machine Interfaces, including displays.
- Develop High Frequency transducer materials and processing support for covert and broadband active.
- Develop lightweight, low cost off board sensors (coherent and non-coherent) in support of multistatics.
- Covert, high-resolution sonar systems for detection and localization of mine-like objects in shallow and very shallow water that extend the operational envelope of existing sonar systems. Sensors, acoustic and non-acoustic, to classify a mine-like object as a highly probable mine or non-mine that extend the operational envelope of existing sensor systems.

Passive Technology Needs (Submarine and Surface Ship Applications)

- Improved detection, classification and localization performance, including the automation of these functions, faster resolution of left/right bearing ambiguity, and improved bearing estimates in all environments consistent with existing arrays and projected future arrays.
- Increased accuracy and speed in mid range (5kyd) detection (probability of detection of 0.9), classification, and tracking of all threat torpedoes and platforms; automated data association and contact management for targets at low false alarm rates (probability of false alarm of .00001).
- The capability to detect torpedo salvo attacks.
- An automated capability to fuse acoustic, sonar related tactical and environmental data to improve performance and reduce operator workload.
- Independently detect, classify, track and localize low radiated noise target submarines by passive sonar means.
- Ability to rapidly detect, classify, and localize close-in threats in all environments. This includes the ability to track incoming weapons, and to automatically maintain tracks during maneuvers.

- Lightweight hull arrays optimized to detect diesel-electric submarines.
- The ability to see in own ship's wake and ability to characterize other wakes.
- Provide affordable handling systems and engineering sensors for large volumetric towed arrays.
- Increased emphasis on fiber optic based acoustic sensors, telemetry, and environmental sensors.
- Provide probabilistic Sonar Equation analysis.
- Provide advanced Target Motion Analysis techniques.
- Development of optical non-acoustic sensors including sensors for measuring towed array shape, temperature, pressure and heading.

Conformal Arrays (Submarine and Surface Ship Applications) Technology Needs

- In-situ coating measurement capability that can locate internal voids or hard spots that create local noise anomalies for flush mounted sensors.
- Laboratory measurement capabilities that provide frequency, temperature and pressure dependent physical properties of submarine hull coatings supporting selection of new materials and manufacturing quality control.
- Numerical techniques to optimize hull coating formulations that mitigate against both acoustic and non-acoustic noise sources.
- Formulations of coating materials that could be used as an outer decoupler to control turbulent boundary layer excitation of embedded accelerometer sensors and to provide physical protection.
- Wide band accelerometers that have a high resonance frequency but retain a high sensitivity measurement capability at low frequency.
- A detailed representation of the vibration field on a full scale submarine as a function of distance from the bow and circumferential position.
- Techniques for locating hull sensors on a coated surface precisely to support both passive and active signal processing.
- Innovative signal processing concepts for conformal arrays that would allow resolution of the backplane noise in sufficient detail to provide acoustic vulnerability assessment and to detect incoming signals for sonar operations.
- Wide band data telemetry systems that can accept a wide range of sensors that address different frequency ranges.
- Technologies to support the Clean Hull initiatives (spherical array elimination), including MF active and MF/HF integration. Provide more emphasis on affordable Conformal Active and Passive.

Surface Ship and Submarine Combat Control Systems (CCS) Technology Needs

- The ability to form an accurate, reliable, and timely composite tactical picture. This includes reliable data fusion and connectivity within the battle-force, and the ability to collect, process, integrate, disseminate, and assess tactical information from all sources (organic and non-organic) in real time.

- The ability to predict the tactical scene to provide the basis for situation assessments and to plan engagements without maneuvering own ship.
- The ability to provide automated techniques for planning, evaluating and assessing potential courses of action, including the capability of providing operator assistance in matching tactical scenarios to Navy tactical doctrine, and from this, developing specific plans for search, attack, monitor and defend activities. Provide planner and assessor modules that will allow automated plan evaluation according to threat evaluations, vulnerability assessments and mission success likelihood.
- Environmental measurement devices, data bases, models and visualization aids capable of supporting operator exploration of present or future geographic, oceanographic and atmospheric conditions. Provide a capabilityfor real time support for tactical picture generation, platform (platforms, sensors, weapons) improved performance prediction, engagement planning, and mission assessment.
- Smart systems capable of rapidly assimilating all the complex variables and tradeoffs associated with torpedo defense scenarios, automatically able to formulate evasion strategies in real time and efficiently communicate data to and rapidly fuse data for the operator.
- The capability to generate and provide the sonar/Command and Control (C2) operator additional contact history and visualization of his current surroundings and a common tactical picture across all platforms in thebattleforce.
- Improved presentation techniques to allow the acoustic operator to assess the past and present acoustic situation and to better analyze the information created by newly acquired systems' processors providing heterogeneous information such as Transient Acoustic Processor (TAP), multistatics, Full Spectrum, and Mine and Torpedo Alertment and Tracking.
- Improved operator displays for enhanced understanding and contact recognition.
- Develop a tactically useful secure acoustic communications capability so that battlegroup commanders can communicate with submarines at speed and depth. The capability will include high data rate communications at short to medium ranges, allowing the transmission and reception of voice, text and images.
- The ability to use Joint Maritime Command Information System and Global Command and Control System (JMCIS/GCCS) communications systems to download and troubleshoot software and to reconfigure hardware aboard surface combatants and submarines remotely.
- The capability to use multiple hypothesis resolution techniques.
- Provide modus field/Intelligent Radial Selection Interpolation techniques.
- Provide voice recognition technologies.
- Provide bistatic and multistatic acoustic performance prediction technology.

- Provide Tactical Decision Aids Adaptability to Environments.
- Provide Cognitive Modeling/Cognitive Task analysis.
- Provide proactive and reactive planning technology.
- Provide measures of effectiveness for Human/Tactical Control system improvements.

Non-Acoustic (Submarine and Surface Ship Applications) Technology Needs

- The capability to characterize own-ship's wake and the wakes of other vehicles, including the turbulence effects on trailing vortex migration and the unsteady effects in vortex generation and migration (maneuvering), including horizontal gradient effects (in the littoral).
- Provide electromagnetic/electro-optical detection technologies.

SURFACE SHIP COMBAT CONTROL SYSTEMS TECHNOLOGY NEEDS

(Note: See Appendix A for elaboration on these surface ship needs).

- Independently detect, classify, track and localize low radiated noise target submarines by passive sonar means.
- Independently detect, classify, track and localize low target strength, low Doppler target submarines by active sonar means.
- Detect, classify and localize torpedoes.
- Detect and localize mine like objects.
- Fuse intra and inter platform sensor data with other operational and intelligence information into a coherent ASW information system that supports asset employment, contact management and the common operational picture.
- Accurately predict and assess system capabilities to support optimum asset employment and identify own system/ship vulnerabilities.
- Reduce supportability and manpower costs.

TORPEDO TECHNOLOGY NEEDS

1. Counterfire Avoidance:
   a. Eliminate the weapon as a source of information for the threat to achieve a Probability of Counterkill (P_{ck}) solution. This need may be met by elements leading to system stealth (quiet launch, propulsion quieting at higher than Torpedo Propulsion Upgrade (TPU) and no altertment from SONAR (during search or the early parts of homing), or very high speed weapons (arrival at the target before reaction is possible).
2. Performance Improvement:
   a. Ensure that Common Broadband Advanced Sonar System (CBASS) and MK54 requirements are met or exceeded in all environments, including the presence of multiple advanced countermeasures. This includes advanced over the side countermeasures launched from surface threats.

3. Close In Engagement:
    a. Reduce minimum range of engagement by a factor of four.
4. Anti-Surface Warfare:
    a. Expanded capability against small high speed surface and very shallow draft threats.
5. Torpedo Availability:
    a. Improve torpedo availability through increased reliability by at least 10%.
6. Warhead Performance:
    a. Ensure that $P_{hit} = P_{kill}$ for all torpedoes.
7. Anti-Torpedo Torpedo (ATT) performance:
    a. Survive a threat launched ATT.

UNDERSEA DEFENSIVE WARFARE TECHNOLOGY NEEDS

- New materials or technologies with which to construct corrosion resistant, externally mounted sonar/torpedo countermeasure launchers, launch tube assemblies, and associated communications and power cables to solve cracking, delaminating, and flooding problems.
- Miniaturization technologies in electronic and mechanical devices that enable safeing and arming of a small (50 pound or less), shaped, explosive warhead to be used in new 6” counterweapons launched from surface ships and submarines.
- Technologies that will localize torpedo launch transients utilizing existing and planned surface and submarine sensors.
- Precision locating technology for use with focused energy or shock wave type responses to threats (platforms or weapons), especially for use in targeting incoming Supercavitating Weapons.
- Location and Fire Control Technologies to be used in conjunction with defensive supercavitating projectiles or torpedoes.
- Miniaturized propulsion systems that provide variable speed mobility to internally launched 3” and externally launched 6” sonar and torpedo countermeasures without decreasing countermeasure mission employment time.
- Technologies that can provide an externally launched, high-speed counter weapon capable of closing to Closest Point of Approach (CPA) and destroying advanced threat torpedoes.
- Technologies that enable extremely quiet launch of externally mounted sonar and torpedo countermeasures and undersea counterweapons.
- Technologies that provide surface and subsurface platform capability to cause mission abort or destroy incoming, high speed, advanced threat torpedoes.

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- Algorithms that provide robust countermeasure rejection capabilities to fielded acoustic intercept systems.
- Robust platform, sensor, weapon, counterweapon, countermeasure and Unmanned Underwater Vehicle/Unmanned Aerial Vehicle (UUV/UAV) behavior/characteristic data models to support the tactical control process.
- Technologies that enable passing continually updated threat and targeting information to and from platform Countermeasure Control Systems and multiple, already launched sonar and/or torpedo countermeasures from surface ships and submarines.
- Advanced processing technologies that enable already launched countermeasures from all platforms to continuously validate specific threat(s) and automatically re-configure to optimum mode.
- Technologies that enhance cover and deception countermeasure performance to ensure break trail capability of submarines.
- Dense energy source technologies that substantially increase sonar and/or torpedo countermeasure mission employment time.

UUV TECHNOLOGY NEEDS

- Advanced, possibly non-traditional, geophysical techniques which are commensurate with mission sensors and yield the required accuracy without the need to surface for Global Positioning System (GPS) fixes over prolonged periods of time.
- An autonomous mission controller that operates correctly and reliably in dynamic (changing) environments and in the presence of unexpected mission events.
- Develop effector and vehicle hydrodynamic control system technologies to allow low speed operation (including hovering) in shallow water environments and significantly improve the available payload volume. This need would include operating in currents of up to three knots.
- Develop a Mission Controller capable of adaptively replanning an ongoing mission.
- Extend the autonomous fault-tolerant control methods to autonomous optimal-performance control methods.
- Improve vehicle hydrodynamic control to be effective in the energetic environments found in very shallow waters.
- An advanced energy source which provides at least 200 W-hr/lb (more than four times the energy density of the Silver Zinc battery), is safe, stable, efficient across a broad operating range (from several hundred Watts to several kW), environmentally benign, and is significantly lower cost than the Lithium Thionyl Chloride battery. The energy source must be compatible with: storage (before and after use) on an SSN; recharge, replenishment, or
- Replacement on an SSN; and launch and recovery from an SSN.
- Extending the advanced energy source goal to 400 W-hr/lb (approximately double Lithium Thionyl Chloride) is a far-term, lower priority, requirement.

- Robust UUV acoustic communication system featuring high data-rate, real time, low bit error rate, and Low Probability of Intercept/Detection (LPI/D) capability in the near term. In order to share critical UUV data with host platform and likewise provide complex mission scripts to the UUV increase the data rate to 5kbps at 10nmi.
- Acoustic communication system capability of greater than 5kbps at 20nmi in the far term.
- Signature control techniques for reduction in UUV radiated noise to or below the level of the Seawolf submarine class at the same speeds.
- Lightweight, low-cost, acoustically and magnetically damped hulls with the highest attainable thermal conductivity.
- Covert launch and recovery of UUVs from either surface ships or submarines.
- Multi-body hydrodynamic modeling and simulation environment to evaluate and develop advanced launch and recovery methods.

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APPENDIX A

SURFACE SHIP COMBAT CONTROL SYSTEMS TECHNOLOGY NEEDS

This appendix to paragraph 4.6 describes technology needs derived from PEO USW's responsibility for acquisition management and life cycle support of the AN/SQQ-89 ASW Combat System. SQQ-89 equipped ships will lead the surface ASW order-of- battle into the second decade of the 21st century and the service life of the newest SQQ-89 ships will extend beyond the year 2030. Thus, the overriding technology need is to enable affordable improvements to keep the SQQ-89 relevant through at least the next two decades. It is expected the network centric capabilities will play an increasing role as future conflicts involving ASW are likely to include coalition forces and Joint force operations. However, it is also recognized that SQQ-89 ships, by virtue of their operational employment in support of missions such as Theater Ballistic Missile Defense, will be required to conduct local ASW operations in which they depend largely on their organic ship and helicopter assets. SQQ-89 systems must capable of supporting the full mix of operations in adverse acoustic environments and without sacrificing the host ship's ability to maintain tactical control at speed. Technologies will be sought which provide the capability to:

- *Independently detect, classify, track and localize low radiated noise target submarines by passive sonar means.* In common with the air, submarine, and surveillance communities, surface ASW shares a strong interest in those towed arrays, sonobouy, and signal/data processing technologies which might restore passive capability against low radiated noise targets at tactically useful ranges. To achieve this capability it is believed that it will be necessary to exploit the full spectrum of submarine acoustic signature vulnerabilities throughout the detection, classification, tracking and localization phases of an encounter. SQQ-89, or more particularly SQR-19, also has certain unique requirements. These derive principally from high interference levels caused by battle force and own ship noise, the need to operate at tactical speeds for sustained periods, and the concurrent availability of LAMPS deployed sonobouys. Sustaining tactical speeds and executing tactical maneuvers also has specific implications for signal processing, data thruput, and sonar decision-making rates, and places a premium on maintaining sensor capabilities while maneuvering. The availability of LAMPS based sensors adds to both system demands and opportunities. All of these issues become particularly acute in many littoral areas where shallow water depths limit towed array cable length and increase both interference and signal propagation complexity. While array improvements will continue to be entertained, recurring cost issues suggest that the most accessible near term improvements are likely to be those which exploit the SQQ-89's planned transition to a COTS based system processing and display configuration.
- *Independently detect, classify, track and localize low target strength, low Doppler target submarines by active sonar means.* The SQQ-89's active sonar is the hull mounted AN/SQS-53. It is included on all in-service and in-production surface combatants except for a few remaining FFG-7 class ships. Since it is hull mounted, the SQS-53 is operationally available in all water depths and sea states and remains functional during the most extreme own ship maneuvers. Originally designed for deep-

water ASW operations it includes convergence zone, surface duct, and bottom bounce modes. A short-range small object detection mode was added several years ago to support an organic mine avoidance capability. The SQS-53 is Navy's principal active search sonar and it will remain so well into the future. However, the SQS-53's utility against below layer / low target strength submarines is extremely limited, particularly so in adverse littoral environments. Reverberation and clutter interference also degrade system performance, particularly against low Doppler targets. A number of steps have been and are being taken to modernize the system and overcome its limitations. The processing and display subsystems of several of the older SQS-53 variants have been converted into COTS based open architecture designs. An Active Adjunct Processor (AAP) intended to facilitate the introduction of improved active classification, normalization and tracking capabilities will be introduced later this year. A new COTS based overall SQQ-89 system design will IOC within the next few years. A multi-function towed array, scheduled for introduction in 2005, will provide a below layer active receive capability for SQS-53 transmissions. Navy's planned introduction of the Airborne Low Frequency Sonar (ALFS) and continued development of low frequency sources will provide opportunities for both mid and low frequencybistactics. These upgrades and additions provide a particularly unique and important opportunity to introduce needed technology. Furthermore, a large number of deployed systems and an extensive environmentally varied echo/interference database are available to aid related technology development efforts. Technologies which reduce the signal excess required for detection, classification and tracking and reduce the incidence of false alarms in high clutter and otherwise adverse environments, as well as those which help system operators deal with the increased workload of added operational modes and new multi-function sensors, are all sorely needed. In combination with the passive needs cited above it should be noted that***the ability to detect, classify, and localize submarines in the vicinity of own ship and other naval forces is the priority need***.

- *Detect, classify and localize torpedoes.* Forthcoming integration of the Torpedo Recognition and Alertment Functional Segment (TRAFS) into the SQQ-89 system will be the basis for substantial improvement in ASW Combatant's torpedo defense capabilities. While current operational requirements will be satisfied it is highly desirable to extend initial detection/classification ranges. It is also foreseen that technological advances will be required to counter quiet electrically driven torpedoes, reduce false alerts, accelerate classification decision processes, and improve localization capabilities in support of countermeasure employment and evasion tactics. Maximum commonality with submarine system technology development is encouraged; however, there are also significant differences in technology needs and opportunities. These differences include: the surface ship's exposure to high acoustic interference levels, increased potential for false alarms, and reactive action restrictions due to the presence of consorts, air operations, etc.; the increased variety of threat weapon types to be countered; differences in available countermeasures; the potentially advantageous availability of non acoustic sensors; and the reduced reluctance to employ active sonar capabilities.

- *Detect and localize mine like objects.* The SQS-53 has been adapted to support an organic mine (or more precisely "mine size object") avoidance capability. Performance of this function is hampered by the system's lack of spatial resolution and limited ability to discriminate against clutter and false contacts at ranges of interest; these limitations are particularly evident against bottomed and close tethered mines. The problem is further compounded by multiping processing and tracker algorithms designed to counter moving contacts. Technologies whichfocus on small/fixed object resolution and classification, possibly deriving from those used in mine hunting specific systems, are needed to enable desired improvements.

- *Fuse intra and inter platform sensor data with other operational and intelligence information into a coherent ASW information system which supports asset employment, contact management and the common operational picture.* ASW success often depends on the ability to fuse seemingly disparate information. This becomes increasingly so against stealthy targets in adverse environments where long range continuous detection and tracking by any one sensor and /or well scripted hand off between sensors is unachievable. The SQQ-89 suite is being upgraded with new contact management software as well as Computer Aided Dead Reckoning Trace (CADRT) and Battle Cube InformationeXchange Systems (BCIXS). While these systems will undoubtedly help with contact management and with maintaining the current battle scene there remains significant need for improvement. Data from periscope detection sensors must be combined with other acoustic and non-acoustic sensors. Since “sniffs and whiffs” may accrue from different sensors, on different platforms, and at different times, contact fusion technology must extend beyond the use of kinematics information alone. Contact management and fusion processes are needed which exploit environmental conditions, historic patterns, operational intelligence, event relationships, classification clues, subjective evaluations, time of arrival, threshold crossing and possibly even inter-array coherence properties. Information technology, display and visualization techniques, quasi or actual artificial intelligence and adaptive systems may all contribute to the needed migration from stand alone sensors, interconnected and interoperable at the operator machine interface, to integrated systems which enable exploiting all available information.Finally, it should be remembered that SQQ-89 ships are called upon to operate in concurrent multi-warfare circumstances and they may therefor be required to simultaneously maintain the sub-surface, surface, air, and land battle scenes; in this environment compliance with Joint Tactical Architecture / Defense Information Infrastructure (JTA/DII) Common Operating Environment (COE) takes on special relevance.

- *Accurately predict and assess system capabilities to support optimum asset employment and identify own system/ship vulnerabilities.* The ability to accurately predict and assess system performance in-situ and in near real time is essential to successful SQQ-89 system employment and effective ASW operations. Inaccuracies in performance estimation which were tolerable when the U.S. enjoyed substantial acoustic margins can now lead to situations where failure is inevitable and may today be the single greatest source of at-sea system effectiveness loss. The problem is compounded by the need to operate in littoral areas which are often characterized by extreme variations in acoustic conditions and where historic environmental data can at best provide a useful basis for advance planning but cannot support effective real time utilization. Technology is needed which can provide organic capability to measure important environmental variables such as sound velocity profiles in real time without constraining ship’s operations and to share and integrate this information across the battle force. The means to convert this environmental information into acoustic performance parameters as a function of range and bearing in at least near real time must also be provided. To achieve the necessary accuracy and consistency, at least certain of these outcomes must be organically compared, reconciled, and merged with actual data being experienced by SQQ-89 sensor systems. In this regard active sonorous, both the present monostatic and forthcoming bistatic systems, are especially useful as they can directly provide reverberation and clutter statistics and, particularly when used in consort with other platforms, an ongoing basis for in situ propagation estimates.

- *Reduce supportability and manpower costs.* The SQQ-89 is a large and complex combat system which, as noted earlier, will be in operational use in numbers for decades to come. Acquisition and total ownership cost has been a PMS 411 focus area for some time and considerable success has been achieved through the application of sound acquisition approaches, systems engineering to increase commonality, and the introduction of COTS based modernization. Technology can also contribute to this area. The U.S. computer industry continues to make extraordinary strides in reducing the cost (and time) of computational processes and display resolution. ONR can facilitate the introduction of these capabilities, and reduce training demands, by employing them to demonstrate new computer aided detection, classification, correlation, and contact management technologies. Similarly, supportability and training costs can be influenced by early attention to user friendly operator machine interfaces and to the application of common displays and functional controls across platforms and warfare areas. In short, systematic attention to good systems engineering practices and to total ownership cost can, and perhaps must, begin with technology development rather than with systems acquisition.

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SHORT-TERM

DIVERSE-SENSOR DATA FUSION

The goal of this effort is to engineer and build a fusion engine that will fuse contact information from a wide variety of passive and active sensors into a single contact representation. The input sensors could be terrestial, sea, undersea or space-based, and of electro-optic, radio-frequency or acoustic origin, both passive (LOB) and active. Secondaryques (e.g., doppler, range rate) should be motion-confirming indicators. This effort will include an analysis of sensor parametrics needed for optimal fusion (e.g., -3db sensor SPA) for future network-centric sensor development efforts.

TCP/IP "LINK"

The goal of this effort is to engineer a means to reliably relay military link information via commercial-standard TCP/IP or Packet-Switched means. The benefit would be to relay Link information via non-dedicated circuits both commercial and military. This would eliminate the need for dedicated Link hardware including antenna and satellite channels.

PIE-IN-THE-SKY

SUBMARINE HIGH-ENERGY LASER

Submarines can be vulnerable to helo-in-the-dip and aircraft on-top encounters. This effort would include development of a high-energy electromagnetic (laser?) weapon whose targeting and firing mechanism is the periscope. The prime-source for the laser could be located within the submarine pressure hull, the energy being guided via optics through the periscope to the target, as designated by the periscope operator.

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TITLE: ADAPTATION OF COMMERCIAL STRUCTURAL CRITERIA TO MILITARY NEEDS

BACKGROUND:

There is a need to integrate commercial criteria into Navy ship procurements in order to achieve reduced cost (potentially millions of dollars) while maintaining military effectiveness. The need exists for analysis to obtain the critical data to evaluate commercial ship construction methods, design rules, systems and structural criteria in a weapons threat environment.

The Navy and commercial ship detail design/fabrication procedures and technology have evolved and matured over the years, but have been optimized to meet different operational requirements and design loads. Commercial ships are designed for sustained operation in well-defined sea states, with frequent inspections. Navy ships must operate in all sea states, cold or warm waters, "in harms way", with more then five years between major inspections and overhauls. The ability of commercial structure, etc to survive the military environment is unknown. It is believed that the proposed approach will help develop modified commercial technology, which will take advantage of the cost effectiveness of commercial industry's design and construction procedures.

BENEFITS:

Advantages/Benefits to the Navy:

- Less expensive warships that still meet operational requirements for warfighting and survivability.
- Improved ability and confidence in both navy and commercial analytical models and tools for designing warships and evaluating commercial designs.
- Increased use of commercial structural practices, structural shapes, and equipment and systems mounting technology by participating shipyards that will improve their ability to do warship and commercial work simultaneously and competitively.
- Introduce dual use (commercial or combatant) ship design capability.

Advantages/Benefits to Industry:

- Improved global competitiveness for shipyards and their industry partners in foreign military sales of warships and equipment.
- Increased use of commercial.
- Design practices by ship design agents participating in USN warship programs which will increase their ability to (compete for) design commercial ships.
- Structural practices, structural shapes, and equipment and systems mounting technology by participating shipyards which will improve their ability to do warship and commercial work simultaneously and competitively.
- A new shipbuilding modeling tool for improved analysis of how to reduce the cost or schedule of either warship or commercial ship construction.

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CONCEPT DESCRIPTION:

It is proposed that the Navy work closely with industry partners to accomplish the following:

- Numerous codes exist commercially that can be adapted to ship structural design. The American Bureau of Shipping (ABS) has rules and guides specifically for the design and construction of commercial vessels. These codes and rules must be evaluated to determine their suitability of providing structure that meets all Navy requirements including operational, maintenance and resistance to weapons. In addition, material selection criteria, design loads selection, and fatigue approaches must be compared. Finally, unique, unwritten, commercially acceptable practices such as the use of bulb angles and lapped connections must be evaluated.
- In comparing and contrasting design methods and criteria the following tasks must be accomplished:
  1. Review, compare, contrasts, and notes differences in commercial and Navy scantling selection criteria. This must include assumptions made and safety factors applied.
  2. Review, compare, contrast and note differences in loads employed in the design, specifically environmental and cargo loads.
  3. Review, compare, contrasts and notes the differences in material selection criteria, welding and inspection requirements.
- Using the above information, establish design requirements with respect to operational capabilities. Using both commercially acceptable criteria and Navy standard criteria, develop the midship section for an auxiliary ship, amphibious ship, and a combatant. Document the steps taken and applicable commercial criteria used.
- Compare, contrast and note the differences between the above developed midship sections for similar ships and comment on causes of any differences. Note any assumptions made during the development of the midship sections that, if modified, would change the outcome.
- Navy structural design criteria assumes use of symmetric stiffeners in many of our ships, especially combatant ships due to weight and stiffener stability considerations. It has been stated that commercially bulb angles and angles are used extensively due to ease of construction and drainage of liquids. The acceptability or resistance of these commercially acceptable members to weapons effects is unknown. UNDerwater EXplosion (UNDEX), Whipping failure criteria (tripping and collapse) for asymmetrical commercial stiffeners (angles and bulbs) has not been quantified, nor verified. This task recommends that commercial stiffeners be surveyed, analyzed and tested to determine their adequacy, as compared to Navy stiffeners for UNDEX loading.
- The shapes aspect of the study shall include:
  1. Analytical assessment and comparison of commercial and Navy buckling criteria
  2. Analytical verification of strength/stability formulations using Finite Element Model (FEM) or other acceptable procedures

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3. Testing plan development for all of the types of shapes that focuses on validating the criteria and FEM
4. Testing and test report
5. FEM modeling and verification with documentation

- Additionally, Navy structural design criteria assume that all connections used in combatant ships is continuous and provides a smooth transition from one member to the other. This permits development of the full plastic capacity of all connected members. Commercial practice permits use of lapped brackets in the primary stress path and discontinuous lugs on shell connections. These details save money but their suitability to weapons effects resistance has not been quantified.
- The connections aspect of the study shall include:
  1. Analytical assessment and comparison of modified commercial connections to Navy connections for their ability to save money and develop the full plastic capacity of the connected members.
  2. Analytical verification of strength/stability formulations using FEM or other acceptable procedures.
  3. Testing plan development for all of the types of connections that focuses on validating the criteria and FEM modeling.
  4. Testing and test report.
  5. FEM modeling report and verification with documentation.
  6. Report of qualified commercial details.
- In addition to the obvious differences in stiffener shape and connection details, the combatant structural design process includes direct and indirect treatment of air explosion and underwater explosion loadings for the basic ship structure. DDS 100-9, DDS 072 and Mil Standard 901 provide examples of direct treatment of weapons effects on hull or foundation structure and contained equipment. Applicability of these documents to ships designed and constructed to commercial standards is unknown.

PROJECT GOALS AND OBJECTIVES:

To save ship construction time and cost through the use of modified commercial structural practices on ships subject to weapons loads.

METHODS AND PROCEDURES REQUIRED FOR ACCOMPLISHING GOALS AND OBJECTIVES:

Navy standard details require full collars around each shell longitudinal in way of all transverse structure, web frames, floors, and bulkheads. If the opening in the pierced transverse member could be modified and lugs could be substituted forcollars, fit up time and hand welding time could be saved. There would also be savings due to the reduction in number of different pieces involved in the construction.

This task recommends that several panel sections be shock tested to determine adequacy of commercial details and stiffener shapes as compared to Navy details and shapes. Each panel will have one of a series of details and shapes, in addition to varying shell plate thickness, and longitudinal and transverse member sizes. These tests can quantify both stiffener shape and connection performances. Measurements will be taken to determine deflections and stresses at several locations on each panel. Finally, once all measurements are taken, FEM models will be developed and verified so those future alternative configurations can be evaluated by computer model in lieu of additional shock tests.

PREVIOUS AND CURRENT RELATED WORK:

1. ABS 1997 Rules for Building and Classing Steel Vessels, Part 3, Appendix 3/C (1995)
2. Navy Design Data Sheet 100-4 Strength of Structural Members dated 15 November 1982
3. Navy Design Data Sheet 100-9 NuclearAirblast Design For Surface Ship Structures dated 27 February 1991

END-PRODUCT DESCRIPTION:

Commercial structural stiffeners (which are cheaper and easier to install), may be substituted for Navy I-beams and tee stiffeners, where appropriate. Modified commercial structural connections (which are cheaper, and easier to install), may be substituted for Navy connections, where appropriate. Other commercial practices may be substituted for Navy practices, where appropriate.

TECHNOLOGY TRANSFER APPROACH:

The FEM analysis program can be sold/licensed to commercial suppliers of structural materials to "shock-qualify" their products. The FEM program will be able to analyze future structural configurations.

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TITLE: VALIDATION OF NEW USA CAPABILITIES

Abstract: The Underwater Shock Analysis (USA) code was used during the SITE III program to analyze the structural response of the large module in the SSTV. Several flaws were revealed in the analysis. The USA code has been modified to eliminate the flaws.Need: re-analyze the response of the module with the new code to determine whether the code modifications are effective.

Benefit: Validation of the improvements made to one of the primary analytical codes in the underwater explosion shock business would assist designers and the government in having confidence in their analytical tools.

TITLE: GUIDANCE DOCUMENTS FOR EXTENSION

Abstract: A guidance document or set of documents which clearly delineate the requirements for shock qualification by extension would be helpful for any business that provides equipment subject to High Impact (MIL-S-901) or UNDEX shock qualification.

Benefit: A large percentage of the equipment qualified to MIL-S-901 is qualified by extension. Many of the extension requests must be submitted more than once due to improper or incomplete original submittals. A guidance document would serve to minimize the number of resubmittals that would otherwise be required.

TITLE: SHOCK PROTECTON FOR PERSONNEL

Abstract: Currently there are shock qualification requirements for equipment; however, there are no requirements to mitigate shock to personnel or methods in place to routinely do this. With the increased usage of COTS and shock isolation implementation, a review of how personnel will be affected as well as possible advantages to implementing additional shock mitigation to personnel should be reviewed and assessed.

Benefit: The ship and personnel should be able to survive a given level of shock loading. Presently we have put most of our emphasis is making the equipment survive shock by equipment hardening and isolation. Now we have reached a stage where the ship and the equipment may survive a given level of shock but the crew may not. This effort will bring a balance between the survival of both equipment and crew.

Concept Description: It is proposed that the Navy work closely with industry to assess the effects on humans that are posed by various proposed or potential shock isolation devices or systems. The hazards posed to the shipboard personnel will be identified and possible means to mitigate those hazards will be identified and evaluated. The evaluation shall consider both the resulting effects on personnel and the revised capability of the system to mitigate shock levels to the installed shipboard equipment.

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TITLE: CHARACTERIZATON OF SHOCK ISOLATORS

Abstract: A wide variety of shock isolators currently exist for use in ship installations and are the details associated with the dynamic characteristics of these mounts are not well known. This effort, which is broken down into two parts which could be completely independently of each other, addresses two different aspects of shock isolators which, when resolved, would aid equipment designs and shipboard installations.

First, many brands of wire rope or other design isolators are currently used to mitigate shock in equipment. To date no study has been done that characterizes the different mounts. The characteristics of the isolators can be used in analytical studies of the equipment response under shock and determine the effectiveness of the different mounts. Without complete, consistent characterization of the mounts, it is not feasible to "validate" the various analytical tools available because one of the critical inputs (i.e., mount characteristics) is not validated and consistent.

Secondly, the use of shock isolation mounts such as coil cable mounts usually carries with the need to add a brace or additional mount at the top of items to prevent excessive motion under way. This practice is fairly expensive and can create arrangement nightmares. Development of a "sway brace" which is either internal to a mount or is inherent in the mount design would eliminate this problem.

Benefits:

1. This study will aid equipment designers in selecting mounting system components which would best provide the extent of isolation required for their components. It would also help in developing analytical methods that can be used to determine shock loading on equipment that is mounted using shock isolators.
2. This part of the study will develop "sway brace" techniques that eliminate the need for top mounts, sway braces, or other devices mounted at the top of otherwise shock isolated cabinets. This will minimize the design effort and simplify shipboard installation.

Concept Description:

1. A standard method for characterization of shock isolation mounts will be developed which provides both static and dynamic characterization. A wide variety of mounts currently in use in the fleet for shock isolations will then be tested, characterized, documented and made available for use.
2. An elastically buckling element in parallel with the isolation mount could act as a sway brace without creating the need for additional structure for a top brace. Including such an element within the mount would be best.

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TITLE: TUNED LOW FREQUENCY MIL-S-901 SHOCK QUALIFICATION TESTING

Abstract: MIL-S-901D requires a 12-16 Hz test fixture for shock qualification of Class II (i.e., resiliently mounted) equipment. This requirement was invoked to implement lessons learned from full-scale ship shock tests. Subsequent to the implementation of this requirement in 1989, the U.S. Navy has greatly increased its use of Commercial-Off-the-Shelf (COTS) equipment and thus has greatly increased its use of shock isolation (e.g., resilient mounting). Therefore the shock qualification requirements contained in Mil-S-901D, while adequate to meet our objectives, could be improved upon to reduce costs and more accurately focus our shock qualification efforts.

There are four areas of advancement that could be made in the Class II shock qualification requirements area and that could potentially result in other improvements in the shock qualification process.

1. Development of a standard 12-16Hz Deck Simulating Fixture for use in the Floating Shock Platforms (FSP). This fixture would have characteristics that adequately simulate the actually observed shipboard shock environment seen during full-scale ship shock testing and also the environment projected to be seen during real threat conditions. This fixture would have a high fixture weight to test equipment weight ratio and thus provide a uniform response across the fixture so that many pieces of Class II equipment could be tested and qualified simultaneously.
2. Development of a tunable deck simulator fixture for use in the FSP that could be tuned from 8 Hz to 25 Hz. This fixture would provide the same benefits as indicated in item 1 but would also provide a capability to improve upon our current MIL-S-901D testing capabilities. This tunable fixture would permit the Navy to conduct testing in a manner that would exercise the resilient mounts in a manner consistent with the actual shipboard environment.
3. Development of both a 12-16 Hz test fixture and a tunable 8-25 Hz fixture that could be used in conjunction with existing test facilities (e.g., the MIL-S-901 Lightweight or Medium Weight Shock Test Machines) would also provide a benefit to the Navy's ability to shock qualify equipment for the Class II environment. This would result in a cost-savings to the programs requiring Class II testing due to the lower costs associated with Lightweight and Medium Weight tests compared to FSP tests. Additionally the number of facilities that could support such testing would be greatly expanded from two to over fifty.
4. Development of a test capability to shock qualify equipment which is either resiliently mounted within a hard-mounted (Class I) rack or hard mounted within a resiliently mounted (Class II) rack. This would permit the rapid, low cost exchange of individual components within a rack while maintaining overall shock qualification.

Benefit: The benefit of accomplishing this is to reduce cost, more accurately reflect the real threat environment, and to increase the number of testing facilities that can meet our Class II shock qualification requirements.

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TITLE: COMPONENT LEVEL SHOCK QUALIFICATION TECHNIQUES

Abstract: MIL-S-901D requires that a principal component be subject to shock qualification testing. This requirement was invoked to test “all-up” units and thus implement lessons learned from actual war damage full-scale ship shock tests. With the proliferation and rapid updating of electronics the U.S. Navy has greatly increased its use of Commercial-Off-the-Shelf (COTS) equipment and has a desire to update equipment in order to introduce the latest technology in a rapid manner. Therefore there is a desire to develop supplemental shock qualification requirements which would permit the use of COTS subsidiary components and sub-assemblies and at the same time continue to meet our objectives of ensuring adequate fleet toughness while minimizing the cost and schedule impact of shock qualifying the updated components.

This paper projects one area of advancement that could be made in the shock qualification requirement for “subsidiary components” and “sub-assemblies.” This would be the development of a “Bench Top Testing Method.” This effort would require the identification of both the environments that the equipment would be expected to be subjected to in the real threat environment and then the test that would adequately simulate that environment. This method could be used as either a “pre-qualification” (e.g., confidence) test or more ideally would be adequate for actual shock qualification testing that would satisfy the Mil-S-901 requirements. Although identified as “Bench Top,” this method need not literally be limited to a “Bench Top” environment.

Benefit: The benefit of accomplishing this is to reduce cost, more accurately reflect the real threat environment, and to increase the ease and rate at which updates can be incorporated into shipboard equipment while still meeting MIL-S-901 requirements.

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TITLE: SHOCK TEST EXPLOSIVE CHARGE IMPROVEMENTS

Abstract: The Navy currently uses a number of different explosive charge sizes for shock qualification of equipment and full scale ship shock testing. These charges typically range in size from 60 pounds up to 40,000 and are usually constructed of HBX-1.

There are four areas of advancement that could be made in the shock test charge arena that would increase the safety and reduce the cost of conducting both shock qualification testing and full-scale ship shock trials.

1. The current test charge containers are constructed of steel and are costly to fabricate and are subject to deterioration due to rusting. A synthetic, roto-molded container is expected to be less costly and would last far longer. The charge sizes that would be of foremost interest to the U.S. Navy for this portion of the effort would be the standard 60-pound and 125 pound charges. These are the most frequently used charges for equipment shock qualification and are the charges used by our commercial testing establishments. Larger charge sizes up to 3,500 or 10,000 pounds may also be of interest.
2. Development of HBX-1 spherical pellet casting and loading techniques for shock test charge production. Current techniques employ mallets to break layers of HBX-1 into smaller, uneven pieces for loading into containers. Spherical pellets would allow more uniform distribution of the explosive in the container, provide more uniform charge density, and lower production costs.
3. Identify a replacement explosive for HBX-1 that has improved characteristics. This explosive would be easier to handle and pour, lower in cost, less sensitive, more energetic, and would provide for more repeatability and constant density. These improvements would ease testing costs and also reduce charge volume and storage costs. Candidate replacements include plastic bonded explosives (PBX) N109, N103, and N105.
4. Development of more environmentally friendly shock test charges is also of interest to the U.S. Navy. A variety of different approaches could be used to improve the environmental issues associated with our shock test charges. Although there have been no problems to date with the chemical composition of our charges and thus the explosive residue left in the water, an explosive which minimizes the amount of residue both in quantity and nature of hazardous materials would be of interest. An alternative approach would be directional shock test charges that place the majority of their energy in an arc towards the ship or model being tested as opposed to the current charges which provide a uniform 360 degree coverage.

Benefit: The benefit of accomplishing this is to reduce cost, more easily reflect the real threat environment, and to increase the ease and rate at which equipment shock qualification testing and full-scale ship shock testing can be conducted.

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SEA 05P – SHIP SURVIVABILITY AND STRUCTURAL INTEGRITY GROUP

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TITLE: STATISTICAL PROCESS CONTROL FOR SHOCK QUALIFICATION REVIEW AND APPROVAL

Need: To develop a statistical control process for the review and approval of shock qualification requests.

Background: Recent acquisition reforms have reduced significantly the ability of the headquarters staff to review shock qualification requests. This, coupled with the fact that more unusual requests are being made have made it imperative that we develop a process to train and maintain reviewers outside of the NAVSEA headquarters staff. To this end, a process is needed to train reviewers, review their reviews on a statistical basis, and provide continuous feedback. Ideally, the process should push qualification reviews and approvals to the lowest level consistent with maintaining a high level of confidence that approved items will in fact survive at the desired attack severity.

Concept Description:

1. Develop framework for statistical process control system.
2. Develop statistical process. Include:
   a. Vendor / Shipyard level
   b. Local SupShip level
   c. Field Activity level
   d. Headquarters level
3. Statistical reviews cover:
   a. Lightweight/Medium Weight
      i) Testing
      ii) Extensions
   b. Heavyweight / Alt Vehicle
      i) Testing
      ii) Extensions
   c. Watertight Integrity testing
      i) Testing
      ii) Extensions
   d. Qualification by Analysis (DDAM / TSA)
4. Develop training materials:
   a. Statistical Process
   b. Basic Qualification Documents
      i) Testing

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ii) Extensions

iii) Analysis

c. Sample Qualification Requests appropriate for each level

d. Statistical Review Process Implementation (to train the trainers)

5. Implement Process

The statistical process should allow for distinctions to be made between routine and unusual qualifications and a method to assign each reviewer a ranking for each type of qualification. The ranking should be used to determine how often to review the reviewer. The process should include methods to improve or lower a reviewer's ranking.

NAVAL UNDERSEA WARFARE CENTER (NUWC)

DIVISION NEWPORT

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UNDERSEA WARFARE MODELING AND ANALYSIS

- Force level/campaign level modeling including multistatic force modeling.
- Tools/models to support advanced fleet concepts including network based collaborative warfare (theater and action group level).
- Tools/models to support USW Investment Strategy (performance vs. cost).
- Information Management System Modeling (sensor to shooter).
- Development of, and system tactical performance evaluation using, Measures of Performance and Measures of Effectiveness.
- Development of, and tactical performance measurement of, improved mission planning aids and adjuncts, from sonar operator to Battle Group Commander.
- Multimodal, e.g., tactical, training,. . ., combatant system architectures.
- Advanced 3D and virtual reality displays for generating forces, platforms, and weapons over a distributed interactive simulation (DIS) network.
- Advanced display, data transfer, and networking technology between live units, shore-based simulations, and computer generated forces to conduct realistic training in the conduct of undersea warfare within a joint mission area context.
- Applications of advanced displays and the generation of synthetic environments for individual platform/system/weapon operations within DIS and for unit level training.

SUBMARINE AND SURFACE SHIP SONAR

- Automatic sensing and control of USW systems (sensor selection, detection method selection, sensor positioning, waveform selection, “hands-off” operation [auto-pilot]).
- Transduction materials technology (piezoelectric materials, including polymers; magnetostrictive materials, both active and passive; underwater acoustic transducers and transduction materials; other relevant undersea materials technology).
- Transducer technology (underwater acoustic transducers and transduction materials).
- Towed array technology (environmentally-adaptive sonar; tactical towed arrays for passive and active sonars [vertical directionality and tactical speed operation also desired]; quick response towed array bearing ambiguity resolution algorithms and hardware technologies; low-cost small acoustic sensors with directional response; hydrodynamic and hydroacoustic analysis for towed and hull-mounted arrays; fiber optic transducers for acoustic, temperature, pressure/depth, and magnetic/heading sensors; improved telemetry designs with increased bandwidth and channel capacity for optical sensors and arrays; optical components [amplifiers, connectors, filters, photo-multipliers, etc.] for towed and hull-mounted arrays; hydrodynamic devices and techniques for generation and control of volumetric array aperture; towed array handling system technology for large aperture arrays and fiber optic arrays to improve operability and reliability; towed, low frequency, lightweight active arrays; low-cost, expendable, deployed array technology; computer-based decision aids for improved performance in sonar detection, classification and localization; synthetic high strength-to-weight ratio load-bearing materials).

- Hull array technology (low-cost, small acoustic sensors with directional response; hydrodynamic and hydroacoustic analysis including finite element analysis for towed and hull-mounted arrays; improved telemetry schemes with increased bandwidth and channel capacity for optical sensors and arrays; optical components [amplifiers, connectors, filters, photo-multipliers, etc.] for towed and hull-mounted arrays; multi-axis motion sensors [conventional and fiber optic] for hull-mounted arrays; large area hydrophone planar arrays and the associated acoustic baffles and decouplers; sonar dome and window materials with frequency-selective transmissivity; hull-mounted arrays with vertical directionality; computer-based decision aids for improved performance in sonar detection, classification, and localization; composite structures [analysis of and manufacturability of]; synthetic high strength-to-weight ratio load-bearing materials; structural acoustics analysis).
- Underwater acoustic measurements technology.
- Concept assessment for USW surveillance (techniques for analysis, modeling, and experimental validation of advanced sonar performance; computational methods for sonar modeling, simulation, and training in littoral warfare environments; computational methods for modeling sonar transducers and arrays with associated structures).
- Full spectrum signal processing for USW (passive sonar signal/post processing techniques to counter postulated quieter threats; passive sonar signal processing for detection, classification, or localization [DCL] of short duration and/or nonstationary signals; accurate passive range estimation algorithms; active sonar signal/post processing, including detection, classification, normalization, and rejection of reverberation, false targets, and clutter; image processing techniques for sonar detection and classification; passive/active signal/post processing techniques for torpedo DCL; automatic processing techniques for passive and active signals and noise associated with a greater number of hydrophones; software development methods for sonar processing including signal, data, and display processing software).
- Data fusion technology (submarine/surface ship [including Light Airborne Multipurpose System (LAMPS)] antisubmarine warfare [ASW] acoustic and nonacoustic data fusion).
- Broadband signal processing for USW (detection resistant active signal/post processing techniques).
- Acoustic communications and acoustic communications which include detection resistant capabilities (adaptation of submarine and surface ship sonars for acoustic communications links capable of supporting voice, text, and imaging [video] transmissions).
- Mine and obstacle avoidance sonars (obstacle avoidance sonar, ultrasonic imaging sonars).
- Multistatic capable sonars (including multistatic sonar Command, Control, Communications, and Intelligence [C3I]).
- Human-machine interface technology (display and/or processing techniques to reduce sonar operator effort in detection, classification, localization [DCL], and related operations; operator machine interface devices applied to sonar, display technologies applies to sonar virtual reality and three-dimensional display concepts for sonar). Coordinated, automatic operation of USW systems using onboard and offboard systems to achieve battlegroup operation as a single “system.”

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SUBMARINE SURFACE SHIP COMBAT CONTROL AND INFORMATION MANAGEMENT SYSTEMS

- Develop software to automate user interface evaluation, including the capture of user actions, timing, GUI widget identifiers, and x-y location, and the analysis of resulting data. This tool must be platform, operating system, and program language independent. (This requirement could be accomplished by a user selectable function, rather than by complete independence.) The analysis component should be capable of identifying and counting repeated sequences within user specified limits.
- Novel sensor information management schemes.
- Contact management (contact state estimation; data/information fusion, discrimination and weighting; multisensor, multicontact data association/processing; over-the-horizon (OTH); offboard data processing; full azimuth contact smart processing vice beam, bin processing; integration of non-traditional, real-time data sources).
- Situation awareness/assessment (acoustic, nonacoustic, on board and off board).
- Decision support for resource management (sensors, weapons, UUVS, countermeasures, and platform).
- Telepresence on tactical platforms using shore-based experts communicating over secure networks.
- Human-computer interaction (data visualization, application of virtual reality for USW, adaptable human-computer interactions concepts).
- Shipboard hardware (computational and graphics engines, high resolution and flat panel displays, reconfigurability/realignment of system resources).
- Software technology (software development tools, runtime environments, software reliability and reusability, real-time scheduling).
- Combat control performance (improved mission area effectiveness, information management metrics, combat systems analysis).
- Modeling, simulation and training (methods for littorals regions, advanced onboard operator and maintenance training techniques).
- Command decision support (common tactical picture generation, disseminated common environmental data, tactical planning, ownship security and self-defense, automation to reduce workload).
- Combat system architecture including application of parallel processing, interface standards for open system architecture, very large-scale integration (VLSI), and distributed networks.
- Image processing, including pattern matching for visual object classification.
- Interior communication for voice, imagery, and data.

ENVIRONMENTAL AND TACTICAL SUPPORT SYSTEMS

- Computer-based warfare modeling, simulation, and analysis including synthetic environments, analysis methodologies using advanced processing techniques and integration to NUWCDIVNPT’s various simulation bed facilities.

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- Environmental and underwater acoustics and nonacoustics (including range dependent aspects).
- Environmental data integration for combat control processing (including range dependent aspects).
- Ocean and target physics for multistatic sonar at long range and low frequency (including range dependent aspects).
- Shallow water modeling, both acoustic and nonacoustic (including range dependent aspects).
- Surface ship systems evaluation and analysis.
- Increasing surface ship sonar analysis capabilities utilizing simulation and stimulation modeling techniques, including upgraded Monte Carlo on NUWCDIVNPT simulation facilities and other DoD simulation facilities.
- Surface ship tactical and fleet support improvements for Surface Ship ASW Analysis Center (SSAAC) sites.
- Rapid prototyping of systems upgrades to conduct C3I, USW, and small object detection and avoidance.
- Signal processing techniques for shallow water localization.
- Environmental adaptation and model-based signal processing.
- Broadband environmental acoustic modeling including shipboard sonar, towed arrays and weapons frequency bands.

SURFACE SHIP USW SYSTEMS

- Surface ship USW electronic systems including active sonar processing of signals from large arrays for significant improvements in detection and false alarm rate.
- Surface ship USW systems engineering including integrating complex outputs of various sensors.
- Gun-launched sensor systems.
- Development of USW system architecture for best utilization of commercial technology.
- Common multifunctional mechanical handling and towing system for variable depth sonar, remote mine reconnaissance system, towed arrays, NIXIE, and special operations equipment.
- Acoustic array concepts with significant forward-looking aperture and minimal hull hydrodynamic impact.
- Unmanned Surface Vehicle (USV) USW intelligent subsystem for distributed sensor and weapon functionality to host system. Automatic sonar system operation based on tactical environment and mission requirements.

SUBMARINE ELECTROMAGNETIC SYSTEMS

- Submarine communications, including broadcast, ship-to-shore, line-of-sight, and satellite systems.

- Radio propagation studies.
- Information coding and modulation.
- Onboard information technology.
- Advanced submarine communication concepts.
- Enhancing the platform as a node within the Naval C3I system.
- Communication equipment design.
- Integration of system equipment.
- Submarine electronic warfare support measures (ESM).
- Sensors and processing equipment for improved omnidirectional and direction finding intercept systems.
- Techniques for radar cross-section reduction for submarine masts and submarine antennas.
- Concepts to assess submarine vulnerability to counter detection for all classes of submarine observables.
- Submarine masts and antennas including analytical design studies.
- Antenna design, testing, and environmental qualification over all electromagnetic frequency ranges.
- Conformal antenna technology, including multifunctional antenna techniques.
- Mast wake and plume reduction.
- Electromechanical and optical cable technologies supporting low loss, pressure resistant, wideband radio frequency data transmission from external sensors to inboard receiving/processing equipment.
- Advanced mast erecting and cable deployment systems, buoyant cables, and towed buoy cables.
- Advanced extrudable materials for buoyant, high strength pressure resistant cable jacketing.
- Materials technologies to enhance mechanical and electrical properties of antenna and sensor radomes over all frequency ranges (fast drain, non-fouling coatings).
- Improved materials for stealth.
- Materials science.
- Multi-stealth material.
- Smart skins.
- Sensor embedded materials.
- Composites for high strength to weight properties for masts and antennas.
- Towed buoy communication devices including antenna design.
- Hydrodynamic analysis and design.
- Nondestructive testing.

- Submarine electro-optics imaging techniques.
- High bandwidth recording techniques.
- High-resolution CCD video cameras (monochrome and color).
- High-speed optical detectors and underwater laser viewing systems.
- Pressure and shockproof fiber optic connectors.
- Fiber optic rotary joints.
- Advanced hydrophobic/antifouling coatings/paints for radomes and masts.
- Fiber optic data links.
- Image processing and enhancement, both real time and post processing.
- Display technology including flat screens.
- Digital image compression and storage technology.
- Wideband analog image storage technology.
- Video data fusion.
- High resolution image intensifiers.
- Analysis of the electromagnetic environment using finite element methods on NUTVCDIVNPT'S computational and simulation facilities.
- Electromagnetic interference (EMI) modeling, analysis, and performance prediction of shipboard systems and components to mitigate the effects of the below decks electromagnetic compatibility environment.
- Use of computer aided design techniques to achieve electromagnetic compatibility (EMC) in design of shipboard equipment and installations.
- Electromagnetic shielding applications of superconductivity or conducting polymers.
- Electromagnetic compatibility test techniques useful for large-scale systems (within one compartment) that would reduce or eliminate unit level testing.
- Applicability of commercial EMI/EMC standards for commercial off the shelf (COTS) equipment used in a shipboard environment.
- Radar sea clutter modeling.

TEST AND EVALUATION

- New lightweight technology in large area, portable underwater tracking ranges.
- Nonacoustic tracking and detection systems.
- Advanced lightweight, portable radiated noise measurement sensors including component elements, sensors and array systems for radiated noise of weapons and other small submersibles.
- Advanced concept hydrophones (fiber optic, velocity or acceleration sensing).

- Low-cost radiated noise measurement systems including component elements, sensors and array systems.
- Autonomous direct sound velocity profiling system which can gather data and communicate with underwater range sensors.
- Low-cost, low-power, in-water signal processing nodes, both cabled and autonomous.
- Long-distance (15-20 nautical miles), high-speed (20Mbps) digital radio frequency telemetry for buoy to ship communications.
- Unaugmented (pingerless) target tracking implementing real-time Matched Field Processing (MFP).
- Optical detection and tracking systems for underwater vehicles and in-air ordnance detonations.
- Advanced 3D virtual displays, data transfer, and networking technology between live units, shore-based synthetic environments, and computer generated forces to conduct realistic training for undersea warfare within a joint mission area context.
- Defense Modeling and Simulation Office (DMSO) compliant wireless mobile networking architectures to support multilevel, secure, encrypted military communications with bandwidth allocation schemes that allow large throughput of voice and video data.
- Rechargeable high-power density battery technologies.
- Underwater inflatable structures forcompact lightweight sensor deployment and retrieval (e.g., Airbeam Structure technology).
- In-situ reconfigurable inflatable sensor frames based on biomechanical models.
- Synthetic Fiber and Composite Material Technology for integrated receivers and transmitters (radio frequency or acoustic).

TORPEDO AND TORPEDO TARGET SYSTEM TECHNOLOGY AND ASSESSMENT

- Coherent broadband processing algorithms for improved target detection against low speed targets at all aspects and for improved countermeasure resistance.
- Methods and algorithms to reduce the probability of targetalertment to torpedo acoustic search.
- Improved post-launch communication techniques between torpedo/submarine and torpedo/torpedo.
- Developmethods/techniques to enable torpedo stowage external to submarine pressure hull.
- Reduced volume, low-cost navigational sensors.
- Operational torpedo processing technology and systems applicable to lightweight and heavyweight torpedo commonality initiatives, including size reduction.
- Application of commercial processing technology and systems to lightweight and heavyweight torpedo sonar signal processing and tactical control functions.

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- Improved torpedo logistical support, maintenance support, and hardware/software acquisition process (heavyweight and lightweight) applicable to commonality initiatives.
- Integrated structural, acoustic, mechanical, and hydrodynamic design codes for paperless design and design simulation.
- Low-cost weapons concepts for low-volume, high-speed targets.
- Non-lethal weapon systems concepts.
- Concepts for regenerative weapons and defensive system.
- Improved torpedo sonar systems, transmit waveforms, sonar beamsets, sonar signal processing, target and false alarm classification techniques for single and multiple pings and functions to support shallow water environment and/or low/zero Doppler target scenario performance improvement.
- Development of affordable, multi-channel, wideband, wide aperture imaging arrays, including associated data acquisition and signal processing systems for use against small, low/zero Doppler targets in shallow water.
- Shallow water environment acoustic models to support upgrade of digital torpedo simulations and hardware in the loop simulators (real-time operation required), including surface and bottom effects and range dependent characteristics.
- Studies and assessments of the effects on the environment of processes and activities utilized in weapons and combat systems development and operation.
- In-air and water entry trajectory digital models, lightweight torpedo configuration dependent, to support performance evaluation of alternate lightweight torpedo configurations and air launch accessories (parachutes, etc.) designs.
- Non-traditional sensor technology and systems and environmental sensing technology and systems applicable to various platforms for shallow water environment and low Doppler target scenario performance improvements.
- Lightweight, stiff, corrosion resistant acoustically damped vehicle structures.
- Technology improvements for lightweight and heavyweight torpedo propulsion silencing, including prime mover, machinery, and propulsor quieting.
- Digital models to support design and evaluation of propulsion silencing technology and/or hardware.
- Digital modeling of electromagnetic fields, beam shapes, and contact interaction to support design and evaluation of potential modifications to torpedo warhead fusing systems.
- Torpedo submarine and surface combatant self-defense technology and systems applications.
- Torpedo operational software protection technology (memory scuttle, encoders, etc.) which prevent compromise of operational software.
- Nonacoustic simulation technology for mobile ASW targets.
- Signal processing algorithms and projector developments to limit surface and bottom effects for shallow water target operation.

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- Wake generation/simulation techniques for mobile target and countermeasure use.
- Anti-torpedo torpedo concepts/technologies.

LAUNCHER AND MISSILE SYSTEMS

- Submarine missiles, mission planning, engagement planning, deployment, and tactics.
- Computerized training and document database management.
- Methods of increasing range, covert targeting, and evasion.
- Corrosion detection, repair and prevention.
- Measurement and control techniques for missile capsules, missile tubes, and torpedo tubes.
- Cruise missile simulation.
- Advanced concepts for submarine self-defense including anti-air warfare.
- Submarine launcher technology including acoustic modeling, transient hydrodynamics, structural analysis, and shock analysis.
- Advanced launcher concepts for the ejection of weapons, countermeasures, and auxiliary devices for submarines.
- Launch dynamics and cable dynamics.
- Advanced materials and manufacturing processes.
- Advanced concepts for pre- and postlaunch weapon/platform communication.
- Advanced concepts for loading, handling, and stowing of weapons aboard submarines.
- Advanced methods for evaluating transient acoustic noise signals from launcher systems.
- Analytical and/or experimental techniques for achieving a better understanding of the physics associated with launching a vehicle from a moving underwater platform.
- Technology and advanced concepts for launch and retrieval of unmanned undersea vehicles (UUVs) from submarines including concepts for platform vehicle communication prior to launch and during the retrieving process.
- Technology and advanced concepts for launch of unmanned aerial vehicles (UAVs) from submarines including concepts for launch control and platform/vehicle communication.
- Technology for using weapon launcher systems as a means for deploying and communicating with off-board sensors.
- Techniques such as drag reduction, noise isolation/suppression/attenuation that reduce the radiated noise, including flow noise associated with the launch of vehicles from submarines.
- Technology that reduces the cost, size or weight of systems/subsystems associated with submarine loading, handling, stowing, shipping, and launching systems.
- Integrated structural, acoustic, mechanical, and hydrodynamic design codes for paperless design and design simulation of launcher systems.
- Technology for the simulation, design and manufacture of elastomeric systems.

HIGH-SPEED UNDERSEA MISSILES, PROJECTILES, AND MUNITIONS

- Supercavitating projectile in-bore, in-water dynamics simulation.
- Supercavitating projectile system targeting concepts and technologies.
- Undersea gun launch concepts and technologies.
- Drag reduction (supercavitation, ventilated-cavity,enveloping-vapor-flow).
- Rocket propulsion and underwaterram-jet power systems.
- High power and energy metal-water combustion systems.
- Stability and guidance control techniques.
- Small warheads and fusing systems.
- Sensors.
- Large vehicle system concepts.
- Undersea systems for detection and tracking of undersea objects.
- Physics modeling of high-Mach-number undersea flows, including high-Mach-number supercavitating or ventilated flows.
- Launch concepts.
- Physics modeling of undersea rocket exhaust interaction with external vehicle flows, including supercavitating or ventilated flows.
- Technology for the measurement and assessment of high-Mach-number supercavitating or ventilated flows.
- Homing/maneuvering/depth independent concepts for high-speed/supercavitating torpedoes.

UNMANNED UNDERSEA VEHICLES (UUV)/AUTONOMOUS UNDERSEA SYSTEMS (AUS)/UNMANNED SURFACE VEHICLES (USV) TECHNOLOGY AND ASSESSMENT

- Precision navigation (traditional and nontraditional methods) including advanced sensor fusion (Doppler velocity sonar [DVS], inertial navigation system [INS], advanced INS concepts, and global positioning system [GPS] updates) applicable to shallow water and open ocean environments.
- Precision covert navigation concepts for UUVs at speed and depth.
- Method to establish GPS fix and establish above-water communications.
- Innovative and cost-effective solutions to improve on the current state-of-the-art capabilities of UUV acoustic communication systems. Areas of improvement include: 1) providing higher data rate capability, including RF; 2) decreasing the computational load required for a given data rate; 3) providing low probability of intercept (LPI) capability; 4) higher data reliability (robustness to errors); 5) lossless and lossy data compression; and 6) any other algorithms which will improve the capabilities for a UUV acoustic communication system.

- Electromagnetic and acoustic signature reduction technologies (both active and passive) including quiet, lightweight, low magnetic signature electric motors, and quiet, efficient propulsors.
- Autonomous control systems for hydrodynamic maneuvering and control of UUVs/USVs especially in littoral environments.
- Intelligent, fault tolerant controller capable of reliable, long-range unattended operation of UUVs/USVs with embedded mission control consisting of mission planning, replanning, collision avoidance, and fault diagnosis and response.
- Oceanographic data collection, including but not limited to temperature, pressure, and current profiling, in support of tactical decision aids and the national oceanographic database.
- Sensor systems for object detection, classification, identification, or avoidance.
- Advanced environmental sensors.
- Autonomous robotics technologies for undersea work.
- High performance, low drag shaft seals.
- Integrated propulsor/motor combinations.
- Novel propulsion concepts.
- High-efficiency, high-energy density, safe long-endurance chemical, electrochemical, and thermochemical energy sources for undersea vehicles.
- Lightweight, stiff, corrosion resistant, acoustically damped vehicle structures.
- Fault tolerant vehicle systems.
- Artificial intelligence.
- Programming technology providing the capability to install tactical software at the operational level.
- Programming technology providing the capability to prevent compromise of tactical software.
- Technology and advanced concepts for launch and retrieval of unmanned undersea vehicles (UUVs) from submarines and USVs from surface ships including concepts for platform vehicle communication prior to launch and during the retrieving process.
- Simulation of undersea launch and retrieval of UUVs.

TORPEDO DEFENSE (LAUNCHERS)

- Universal surface ship launcher for countermeasure devices up to 12.75-inch diameter.
- Common data and power transmission with countermeasure device and universal launcher.
- No maintenance, unmanned surface ship launcher design.
- Advanced launcher concepts (including external and tubeless concepts) for the ejection of weapons, countermeasures, and auxiliary devices from surface ships.
- Technology for the simulation and design of torpedo defense launchers.

- Low-cost, modular, portable simulators for on-board training.

TORPEDO DEFENSE (MODELING AND SIMULATION)

- Acoustic and magnetic properties within various surfaceship wakes.
- Acoustic and magnetic surface reverberation.
- Acoustic and magnetic multiscatter effect within various wakes.
- High-speed torpedo operation at shallow depths within various wakes.
- Models addressing operation in a shallow water environment (propagation loss, multiple bottom types, performance prediction tools, etc.).
- Models and concepts addressing Terminal Defense issues, fuze influence technologies, and advanced countermeasure operations and tactics.
- Low-cost, modular, portable stimulators for on-board training.

TORPEDO AND ACOUSTIC COUNTERMEASURES/COUNTERMEASURES DEVICES TECHNOLOGY

- Technology supporting mobile and stationary surface and submarine launched jammers and countermeasures (CMs) capable of operating in layered defense scenarios and in open ocean and/or littoral environments.
- Improved countermeasure systems, transmit waveforms, beam patterns, sound pressure levels, endurance, in-situ design, and classification smart adaptive processing, mobility, fuze influence technologies, and acoustic communication links.
- Passive/active signal processing techniques for countermeasure application especially the following technologies: wavelet theory, time frequency distributions, full spectrum processing, transients, digital signal processing, parameter/feature extraction, neural networks, curve fitting routines, clustering algorithms, fuzzy logic, field programmable gate arrays (FPGA), application specific integrated circuits (ASIC), smart adaptive processing, and active signal processing for detection, classification, and localization (DCL).
- Ocean physics simulation and analysis including: broad band environmental acoustic modeling — shallow water; blue water; low, sonar, weapon, high, and very high frequency; wake physics — acoustic properties of wakes; nonacoustics, i.e., electromagnetic, laser.
- Small affordable broadband high efficiency, high power, high fidelity acoustic sensors, transducers, and arrays especially the following technologies: split ring, barrel stave flextensional, flextensional, rare earth materials, piezoelectric materials, plasma, piezo rubber, and/or fiber optic hydrophones, wideband arrays, planar arrays, and lead, magnesium, niobate material.
- Undersea material technology: small expendable high-energy primary batteries — metal hydrides, polymer, and lithium ions.
- CM system engineering including packaging, versa module European (VME) extension instrumentation (VXI), simulation based design tools, commonality, modular, rapid prototyping, and CM device operation in multiple device environment including CM data acquisition systems in support of CM development and testing in laboratory and at sea.

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- Computer-based warfare modeling, simulation, and analysis including synthetic environments, analysis methodologies using advanced processing techniques and integration to NUWCDIVNPT's various simulation bed facilities. To specifically include engagement modeling; a CM test bed providing for CM signal design and assessment, CM logic design, real-time algorithm development, and on-line threat database; distributed interactive simulation (DIS) networks to integrate to major weapons analysis facilities; advanced displays; and software development tools to support state-of-the-art CM development.
- Dual-use (sonar and torpedo) countermeasure that fits in existing launchers.

THERMAL AND ELECTRIC PROPULSION (FOR TORPEDO, TARGET, UUV, MOBILE MINE AND COUNTERMEASURE APPLICATIONS)

- High energy fuels and oxidants for internal and external combustion engines, hot gas expander engines, and gas turbines for use in torpedoes, targets, mobile mines, and unmanned undersea vehicles (UUVs). Emphasis is on propellants and combustion products that have minimal safety restrictions, personnel hazards, and environmental impact as well as low overall system life cycle costs.
- Battery, semi-fuel cell, and fuel cell technology including a) high rate primary and secondary batteries for high-speed underwater vehicles and b) low rate rechargeable energy systems for long endurance missions in unmanned underwater vehicles (UUVS). Systems should be energy and power dense, safe, free of environmental impacts throughout the cycle from production to disposal, and have reduced life cycle costs. Rapidly rechargeable secondary systems and smart chargers for high and low rate applications are also desired.
- Analytical models to perform in-depth optimization analyses on electric propulsion systems, including secondary and primary high energy density battery systems together with permanent magnet, brushless, DC motors, and on thermal propulsion systems, including fuels, oxidizers, combustion systems, thermal engines, and heat exchangers.
- Analytical models to evaluate the transient behavior of aluminum aqueous battery and semi-fuel cell systems applicable to high energy density torpedo and/or UUV applications.
- Studies and assessments of primary and rechargeable battery systems regarding, but not limited to, the energy and power density, cycle life, affordability, and safety as appropriate to torpedo, target, mobile mine, countermeasure, and UUV systems.
- Electric motors and controllers for undersea systems including main propulsion, auxiliary thrusters, and other functions. Systems should be compact, lightweight, efficient, low cost throughout their life cycle, and have very low torque ripple and structural vibrations. (The power ranges of interest are 10-40 hp and 100-500+hp.)
- Affordable propulsion systems for three-inch and six-inch countermeasure devices.
- Novel propulsion concepts, including hybrid power cycles.
- Integrated motor/propulsor combinations, and quiet, efficient flooded motor concepts.
- Flow of conducting fluids in the presence of strong electric and/or magnetic fields. Effects of electrolytic bubbles, chemical reactions, and electromagnetic forces should be considered either theoretically and/or experimentally. Applications include flow in aqueous battery systems, magnetohydrodynamic propulsion, and electromagnetic flow control.

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- Studies and assessments of propulsion system technology on the performance of tactical scale undersea vehicles (torpedoes, targets, UUVs, and countermeasures).
- Micro electro magnetic system (MEMS) devices for energy conversion and micro-sensor and controller applications.
- High-strength, rare earth permanent magnet materials and fabrication processes.
- Studies and assessments of advanced torpedo, target, mobilemine, and UUV propulsion system production and life cycle costs.
- Novel high-power (10-50 hp) propulsion concepts for small diameter (< 12”) UUVs.

MATERIALS

- Engineered coatings.
- Cost engineering in composite manufacturing.
- High-strength, lightweight, low cost, corrosion resistant, metallic material.
- High-strength, lightweight, low-cost, flame-resistant, non-metallic materials.
- High-strength, rare earth permanent magnet materials and fabrication processes.
- Lightweight, nonferrous, shielding of electromagnetic energy.
- Multisignature materials (e.g., radar and infrared low observable materials).
- Acoustic signature reduction materials.
- See materials requirements listed in other technological areas.

COGNITIVE NEUROSCIENCE (CNS) RESEARCH AS APPLIED TO UNDERWATER SYSTEMS

- Applications to state-of-the-art underwater Fully Automated Systems Technology (FAST) involving:
  - Automatic sonar detection, classification and/or localization of diverse acoustic sources.
  - Autonomous guidance and control.
  - Autonomous perception, data fusion, analysis and decision making.
  - Adaptive reasoning.
- Applications from on-going research in:
  - Biologically based visual and auditory systems.
  - Architectures involving autonomous agents.
  - Improved computational models based on biologically accurate neurons.
  - Sub-neuronal computations including microtubules.
  - Network of network computing.
  - Information transfer to/from human using multiple senses for input to human and multiple methods of human input to system (five senses for input; voice, feet, hands, eyes, etc. for input to system).

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